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(54) **Siloxane MQ resin vesicles and entrapment**

MQ-Siloxanharze-Vesikel und Einschlussprodukte

Vésicules de résine de siloxane MQ et piégeage

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**EP-A- 0 483 465 EP-A- 0 563 881**  
**US-A- 3 887 601 US-A- 5 364 633**

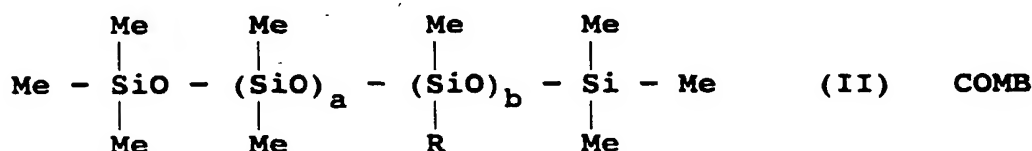
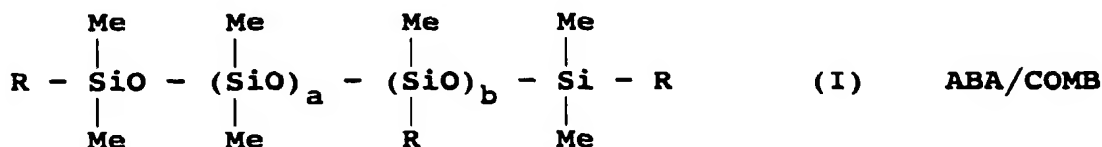
- **KIRK-OTHMER: "Encyclopedia of Chemical Technology, Third Edition, vol.22" 1983, JOHN WILEY & SONS. XP002021674 \* page 344, line 27-48 \***

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## Description

[0001] This invention is directed to siloxane MQ resin based polyethers and to the formation of vesicles. More particularly, the invention is directed to vesicles formed from certain water dispersible siloxane MQ resins and the entrapment of water-soluble and water-insoluble substances.

[0002] The usefulness of certain "linear" polydimethylsiloxane polyether copolymers for forming vesicles has been demonstrated in US Patent 5,364,633. According to the '633 patent, vesicles are formed with linear organosilicon compounds with one of the formulas:



[0003] In the formulas, R is methyl,  $-(\text{CH}_2)_x\text{O}(\text{C}_2\text{H}_4\text{O})_y(\text{C}_3\text{H}_6\text{O})_z\text{R}'$  or  $-(\text{CH}_2)_x\text{N}^+\text{R}_3\text{A}^-$ , provided at least one R radical is not methyl. R' is hydrogen atom, methyl radical or an acyl radical. R" is a C1 to C6 alkyl radical, phenyl, benzyl or  $-\text{CH}_2\text{CH}_2\text{OH}$ . The counterion A<sup>-</sup> is chloride, bromide, iodide, cyanide, methyl sulfate, salicylate or a dodecylsulfate radical. Representative of these linear compounds are  $\text{R}[\text{Si}(\text{Me})_2\text{O}]_{14}\text{Si}(\text{Me})_2\text{R}$  in which R is  $-(\text{CH}_2)_3(\text{OCH}_2\text{CH}_2)_7\text{OH}$ ;  $\text{R}[\text{Si}(\text{Me})_2\text{O}]_{14}\text{Si}(\text{Me})_2\text{R}$  in which R is  $-(\text{CH}_2)_3(\text{OCH}_2\text{CH}_2)_{12}\text{OH}$ ;  $\text{Me}_3\text{SiO}[\text{Si}(\text{Me})_2\text{O}]_{22}[\text{SiMeRO}]_2\text{SiMe}_3$  in which R is  $-(\text{CH}_2)_3(\text{OCH}_2\text{CH}_2)_{12}\text{OH}$  and  $\text{Me}_3\text{SiO}[\text{Si}(\text{Me})_2\text{O}]_{103}[\text{SiMeRO}]_{10}\text{SiMe}_3$  in which R is  $-(\text{CH}_2)_3(\text{OCH}_2\text{CH}_2)_{12}\text{OH}$ .

[0004] EP A 0 483 465 describes the use of tetra(acyloxy) silanes in the formation of vesicles.

[0005] The present invention, however, is distinguished from the prior art in the provision of "cross-linked" siloxanes which are chemically more inert and in the unexpected finding that vesicles can be formed from cross-linked siloxanes which are not previously known to possess this unique capability. Thus, prior to our invention, it was not known to form vesicles from cross-linked siloxane molecules, such as the MQ resin based polyethers described herein; nor was it known to use water dispersible cross-linked siloxane MQ resins for entrapping water-soluble and water-insoluble substances.

[0006] US Patent No 3 887 601 describes MQ resin surfactants and their use in the preparation of polyurethane foams. Premixes are prepared including the MQ resin surfactant, water and other essential starting materials for polyurethane foams and problems of premix incompatibility are overcome by inclusion of additional ingredients either a water soluble organic surfactant or a water soluble glycol. There is no teaching of the formation of vesicles.

[0007] Because of the nature of the siloxane linkage, surface active siloxanes do not follow the usual rules of surfactant activity, with regard to such things as aggregate formation and solubilization. Therefore, to even find a siloxane molecule which is able to form vesicles is quite surprising and unexpected. What is even more surprising and unexpected is that having once pinpointed a particular siloxane molecule for vesicle formation, that the vesicle formed from the siloxane is also useful to entrap substances.

[0008] The advantages and benefits derived by the use of surface active siloxanes in vesicle formation and substance entrapment, include the fact that siloxanes possess a non-hydrocarbon character and, therefore, provide a different set of physical properties than is currently available with hydrocarbon-based surfactant molecules. Secondly, surface active siloxanes have been found to form vesicles "spontaneously" on contact with water and, therefore, they eliminate

the use of energy intensive processes such as sonification, which are required for non-siloxane based surfactants. Thirdly, because the siloxane backbone offers chemically reactive sites, it is possible to easily exploit the formation of polymerized vesicles.

**[0009]** It is known that aqueous dispersions of lipids in the form of particles having a lamellar structure termed "liposomes", are excellent vehicles for the delivery or encapsulation of pharmaceutical substances. As a cosmetic system, they facilitate the supply of lipids and water to the stratum corneum and are able in the absence of a moisturizer, to prevent the occurrence of dry skin. As a vehicle, they also effectively facilitate the transport of diverse substances such as moisturizers, tanning agents and sunscreens into the stratum corneum and, furthermore, prevent subsequent elimination by water washing.

**[0010]** In that context, lipid means specifically a class of surface active lipids, for example, phospholipids or lecithins which are dispersible into water to form lamellar phase particles or liposomes. Liposomes are single or multi-layered, spherical, globular or tubular vesicles, the membranes of which consist of a bilayer of amphiphilic lipid molecules. Most cosmetic and pharmaceutical liposomes are composed of various phospholipids of natural, semi-synthetic and synthetic origin.

**[0011]** The term vesicle refers to a structure consisting of a closed bilayer membrane envelope. Vesicles are often globular or tubular in shape but can be quite irregular. In the context of the present invention, however, vesicles made using surface active siloxanes are not liposomes in the sense that they are not actually prepared from materials recognized as lipids. Rather, a liposome is a specific type of vesicle prepared from lipid amphiphiles.

**[0012]** Unsolved problems relating to large scale production, stabilization and safety of liposomes may hamper development of this type of technology. On the other hand, vesicles formed using the surface active siloxanes of the instant invention offer a potential for overcoming these problems, because of the different physical properties and the distinctly non-lipid character of vesicles formed from such surface active siloxanes.

**[0013]** It is an object of this invention to provide a method of entrapping a water-soluble substance in a vesicle formed from a siloxane MQ resinous material. According to this method, a mixture is formed by dissolving the water-soluble substance to be entrapped in water, whereupon the siloxane is added to the mixture. The mixture is mildly agitated and excess water and water-soluble substance to be entrapped are removed from the mixture.

**[0014]** It is also an object of the present invention to provide a method of entrapping a water-insoluble substance in a vesicle formed from a siloxane MQ resinous material. According to this embodiment, the water-insoluble substance to be entrapped is dissolved in the siloxane and the water-insoluble substance and siloxane are mildly agitated.

**[0015]** Thus, the present invention provides a method of entrapping a water-soluble or water-insoluble substance in a vesicle formed from a surface active siloxane comprising forming a mixture by:

- (a) dissolving the water-soluble substance to be entrapped in water and adding a surface active siloxane; or
- (b) combining the water-insoluble substance and a surface active siloxane;

and agitating the mixture, the surface active siloxane consisting of tetravalent  $\text{SiO}_2$  units and monovalent  $\text{R}_3\text{SiO}_{1/2}$  and  $\text{R}'\text{R}_2\text{SiO}_{1/2}$  units, the ratio of monovalent units to tetravalent units being from 0.4:1 to 2:1 and from 40 to 90% of all monovalent units being  $\text{R}'\text{R}_2\text{SiO}_{1/2}$  units, and, optionally, not more than 5% in total of trivalent units  $\text{RSiO}_{3/2}$  or divalent units  $\text{R}_2\text{SiO}_{2/2}$ , wherein R denotes a monovalent hydrocarbon group having up to 8 carbon atoms and R' denotes a polyoxyalkylene group terminated by a hydroxyl group, an alkyl group, an aryl group or an acyl group, wherein the siloxane is present in an amount of from 0.1 to 40.0 percent by weight and the water-soluble or water-insoluble substance is present in an amount of from 0.1 to 10.0 percent by weight, the balance being water or a cosolvent.

**[0016]** The advantages and benefits of the invention can be appreciated when it is considered that prior to our invention, surfactants known to form vesicles were principally dialkyl cationic surfactants and phospholipids. There is no structural resemblance between these classes of organic surfactants and the surface active siloxanes employed herein.

**[0017]** Rather, the siloxanes of this invention are polymeric cross-linked molecules which contain a wide variety of molecular species. It is surprising that such a polydisperse mixture would form a highly organized structure such as a vesicle. It is even more unexpected and surprising that complex molecules such as cross-linked resinous siloxanes would pack themselves together into an orderly, liquid crystalline state.

**[0018]** While surface active siloxanes are known to be useful in the manufacture of polyurethane foam, as wetting agents and as surface-feel modifiers, the capability of siloxane MQ resin based polyethers to form vesicles for entrapping water-soluble and water-insoluble substances is totally unexpected. Comparable organic materials having similar uses are not known to possess the additional capability of vesicle formation and entrapment.

**[0019]** Another benefit and advantage derived by this invention is the facility with which the siloxanes of the invention form vesicles. The formation of stable vesicles from known dialkyl cationic surfactants and phospholipids require very involved and special procedures including the necessity of high energy mixing in their preparation. In our invention, however, vesicles formed from water dispersible siloxane MQ resinous materials are formed with relative ease and it

is simply a matter of mixing the siloxane with water.

**[0020]** Vesicles, sometimes loosely referred to as liposomes, are surfactant molecules which form closed layered structures when dispersed in water. They are constructed of alternating layers of surfactant bilayers which are spaced by aqueous layers or compartments arranged in approximately concentric circles. If multilayered vesicles are subjected to ultrasound or vigorous agitation, the multilayered structure can be disrupted to produce a single bilayer assembly, which consists of a unilamellar vesicle in which a portion of the aqueous phase is entrapped within a single bilayer assembly. Typically, a vesicle has a diameter of 30 to 100 nanometers (0.03 to 0.1 micrometers).

**[0021]** Vesicles are able to entrap within their assembly a portion of the aqueous phase present at the time of their formation. This provides a convenient vehicle for the inclusion within the vesicle of water-soluble substances. Water and hydrophilic compounds are entrapped in the central cavity of the vesicle between planes of the hydrophilic head groups. Water-insoluble substances can also be incorporated into the vesicle, although the water-insoluble substance locates itself between planes of the hydrophobic head groups of the vesicle system.

**[0022]** Examples of some of the types of water-soluble substances which can be entrapped according to the invention are conditioning agents such as Vitamin C, Vitamin H (biotin), gelatin and hydrolyzed collagen; deodorant actives such as Triclosan; antiperspirant salts such as aluminum chlorohydrate and aluminum/zirconium glycine; preservatives such as salicylic acid, DMDM hydantoin and cetyl trimethyl ammonium bromide; sunscreens agents such as 4-aminobenzoic acid (PABA) and 2-phenylbenzimidazol-5-sulfonic acid; humectants such as glycerine, sorbitol and propylene glycol; colorants such as Violet No. 2, D & C Red 22 and D & C Green 8; enzymes such as papain, trypsin and chymotrypsin; drugs such as aspirin and nicotine; and hydroxy carboxylic acids such as hydroxyacetic acid (glycolic acid).

**[0023]** Examples of some of the types of water-insoluble substances which can be entrapped according to the invention are conditioning agents such as Vitamin A, Vitamin E Acetate and lanolin oil; preservatives such as 2-mercaptopyridine-1-oxide; sunscreens agents such as homomenthyl salicylate (homosalate) and 4-methoxy cinnamic acid isoamyl ester; humectants such as lanolin alcohol, cetearyl octanoate and sodium stearoyl lactylate; colorants such as stearamide DIBA stearate and ethylene glycol monostearate; emollients such as mineral oil, jojoba oil and polydimethylsiloxane; and drugs such as nitroglycerin.

**[0024]** Water-soluble substances are entrapped by dissolving the substance in water, adding the surface active siloxane, applying a minimum of agitation to the mixture by mild shaking and removing excess water and substance in the external phase by centrifugation, dialysis or size exclusion chromatography. Water-insoluble substances are entrapped by adding the substance into the surface active siloxane, followed by applying a minimum of agitation to the mixture by mild shaking. No removal step by centrifugation, dialysis or size exclusion chromatography is required. A suitable co-solvent such as chloroform may be included however. The vesicle containing the entrapped water-insoluble substance can then be used by dispersing it in an aqueous system if desired.

**[0025]** The siloxane MQ resin based polyethers of this invention form vesicles when used in low concentration levels up to concentration levels at or near the lower boundary of the lamellar liquid crystal phase. Thus, the siloxanes are employed in an amount of from 0.1 percent by weight to 40.0 percent by weight, preferably in a range of from 0.5 to 20.0 percent by weight. The water-soluble substance to be entrapped in the vesicles formed from these siloxanes is employed in an amount of from 0.1 percent by weight to 10.0 percent by weight, with the balance of the composition being water. The water-insoluble substance to be entrapped in the vesicles formed from these siloxanes is likewise employed in an amount of from 0.1 percent by weight to 10.0 percent by weight, but the balance of the composition is a suitable co-solvent such as chloroform.

**[0026]** Excluding water and co-solvent, vesicles of the present invention comprise 1-99.7 percent by weight of the surface active siloxane and 0.3-99 percent by weight of the water-soluble or water-insoluble substance.

**[0027]** Useful organosilicon compounds for forming vesicles of this invention are materials which have monovalent siloxane units of the formulae  $R_3SiO_{1/2}$  and  $R'R_2SiO_{1/2}$  and tetravalent units of the formula  $SiO_{4/2}$ . A minor amount of trivalent units  $RSiO_{3/2}$  or divalent units  $R_2SiO_{2/2}$  can also be present, but they should not exceed 5% of all siloxane units present in the compound. The ratio of monovalent units to tetravalent units is from 0.4:1 to 2:1. Suitable organosilicon compounds may be liquid or solid at ambient temperature, e.g., 20°C. R denotes hydrogen atom or a monovalent hydrocarbon group having up to eight carbon atoms. R may be an alkyl, aryl, alkenyl, alkynyl, alkaryl or aralkyl group. Examples of such groups include methyl, ethyl, propyl, hexyl, phenyl, vinyl, allyl, hexenyl, propargyl, tolyl, phenylethyl and styryl groups. It is preferred that at least 80% of all R groups in the organosilicon compound are lower alkyl or aryl groups, most preferably methyl groups. It is even more preferred that substantially all R groups are methyl.

**[0028]** The R' group denotes a polyoxyalkylene group which is preferably terminated by a hydroxyl group. Other terminating radicals which can be used are an alkyl group such as methyl, ethyl or propyl; an aryl group such as phenyl; or an acyl group such as acetyl. It is preferred that at least 50% of all oxyalkylene groups in the polyoxyalkylene group are oxyethylene groups. Any other oxyalkylene groups present are preferably oxypropylene or oxytetramethylene groups. It is most preferred that at least 80% of all the oxyalkylene groups be oxyethylene groups. It is also preferred that the polyoxyalkylene groups be attached to a silicon atom via -SiC- bonds, as such bonds are believed to be more

hydrolytically stable than -SiOC- bonds. The polyoxyalkylene groups preferably have a number average molecular weight which is at least 300, more preferably at least 500, but it is preferred that the polyoxyalkylene have a number average molecular weight which does not exceed 1000.

**[0029]** Organosilicon compounds suitable in forming vesicles of this invention are those in which 40 to 90% of all monovalent units present have the formula  $R'R_2SiO_{1/2}$ . Organosilicon compounds which are used preferably have a ratio of monovalent to tetravalent siloxane units which is above 1:1, more preferably from 1.3:1 to 1.8:1 and most preferably from 1.4:1 to 1.6:1. Organosilicon compounds having the preferred ratio of monovalent over tetravalent siloxane units tend to be liquid at ambient temperatures and are therefore easily mixed. It is preferred that the organosilicon compounds be those which are still liquid. Solid organosilicon compounds can also be used, but would be provided as a solution or dispersion in a suitable solvent or other medium.

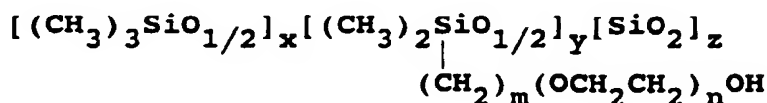
**[0030]** These organosilicon compounds are made according to known methods. The preferred method includes the reaction of organosilicon compounds essentially consisting of tetravalent  $SiO_2$  units and monovalent units of the formulae  $R_3SiO_{1/2}$  and  $HR_2SiO_{1/2}$  in the required ratios, with alkenyl endblocked polyoxyalkylene compounds, e.g., vinyl or allyl endblocked polyoxyethylene polymers or vinyl or allyl endblocked polyoxyethylene-polyoxypropylene copolymers. SiH containing organosilicon compounds which are used in the preparation of suitable organosilicon compounds are known compounds and have been described together with their preparation method in US Patent No. 4,774,310 (EP 0 251 435).

**[0031]** The invention is further illustrated in the examples in which parts and percentages are expressed by weight unless otherwise stated.

## EXAMPLE I

### Preparation of MQ Organosilicon Compounds

**[0032]** In a flask equipped with a dropping funnel, condenser, thermometer and stirrer, y moles of  $CH_2=CH-CH_3(OCH_2CH_2)_{12}OH$  were charged together with 25 microliters of a 5% solution of chloroplatinic acid in isopropanol, 200 mL of toluene and 0.5 g of sodium acetate. The dropping funnel was charged with 200 g of an organosilicon resin of the formula  $[(CH_3)_3SiO_{1/2}]_x[(CH_3)_2HSiO_{1/2}]_y[SiO_2]_z$  which was added to the mixture under agitation as soon as the flask contents had reached a temperature of 90°C. Upon completion of the addition, the mixture was heated to reflux temperature and maintained until all SiH groups had reacted. This was monitored by infrared spectroscopy. The resulting organosilicon compound was analyzed and found to have the formula



wherein m was 3, n was 12 and the ratio of x/y/z had the value shown in Table I for Compounds MQ1 to MQ6. Preferably, the x/y/z ratio is 0.5-1.5 to 0.3 to 0.6/1. The values of m and n can be in a range of 2-8 and 7-35 respectively, and still provide suitable compounds. All compounds were liquid materials and their viscosity is shown in Table I.

TABLE I

	Ratio of x/y/z	Viscosity (mm <sup>2</sup> /s)
MQ1	0.63/0.37/1	10,000
MQ2	0.79/0.41/1	4,000
MQ3	0.94/0.46/1	1,000
MQ4	1.10/0.50/1	600
MQ5	1.26/0.54/1	300
MQ6	1.42/0.58/1	100

**[0033]** This same method was used for making MQ7 which had the x/y/z ratio of MQ3 and the oxyalkylene units -  $(CH_2)_3(OCH_2CH_2)_3OH$ .

EXAMPLE II

**[0034]** Vesicles were prepared from surface active siloxanes and their entrapping efficiency was evaluated. The surface active siloxanes employed are shown in Table I. There was initially prepared two milliliters of a two weight percent solution of each siloxane in a buffer solution containing 60 mM calcein, a water-soluble fluorescent dye known as Fluorexon, which is chemically {bis[N,N-bis(carboxymethyl)aminomethyl]fluorescein. At the concentration employed, the calcein dye was self-quenching and not fluorescent. All the solutions were brown in color. Each solution contained vesicles formed from a siloxane entrapping a fraction of the solution volume in an excess of the solution. The calcein dye was removed from the solution external to the vesicles by size exclusion chromatographic separation, using a SEPHADEX® column and also by ultracentrifugation. Once the calcein dye external to the vesicles had been removed, any leakage of the dye out of the vesicle was detectable, because the calcein dye became fluorescent in the lower concentration of the environment external of the vesicle. The leakage rate was accordingly quantified by monitoring fluorescence as a function of time.

EXAMPLE III

**[0035]** One-half of each of the solutions prepared in Example II was ultracentrifuged at 40,000 rpm/150,000 G (4188 rad/s) for thirty minutes. A small brown pellet of vesicles formed from the siloxane was visible in the bottom of each of the solutions. The supernatant liquid was poured off and the vesicles were redispersed in a fresh buffer solution and again ultracentrifuged under the conditions noted above. Again a small brown pellet appeared at the bottom of each of the solutions. Once more, the supernatant liquid was poured off and the vesicles were once again redispersed in a fresh buffer solution. The solutions each appeared to be light brown in color, which indicated the presence of vesicles entrapping the concentrated calcein dye solution. Fluorescence increased very slowly, which indicated that the vesicles formed from the siloxane did not leak rapidly. The addition of twenty microliters of a ten percent by weight solution of sodium dodecylsulfate (SDS) dissolved the vesicles and caused a sudden and dramatic rise in fluorescence, which demonstrated conclusively that entrapment had occurred for each of the siloxanes. The entrapped volume was determined with the aid of a standardization curve for calcein dye.

EXAMPLE IV

**[0036]** The other one-half of each of the solutions prepared in Example II was passed twice through a small prepacked size exclusion SEPHADEX® column and a cloudy middle fraction was collected. The solutions were washed through the column using an iso-osmotic buffer solution. SEPHADEX®, a trademark of the Pharmacia Biotechnology Group of Piscataway, New Jersey, is a dry insoluble powder column packing composed of microscopic beads that are synthetic organic compounds derived from the polysaccharide dextran. The dextran chains are cross-linked to provide a three-dimensional network and functional ionic groups are attached to the glucose units of the polysaccharide chains by ether linkages. In the SEPHADEX® size exclusion column, small calcein dye molecules "visit" the holes in the SEPHADEX® column packing and, therefore, pass through the column at a much slower rate than vesicles formed from the siloxane. Following treatment of the solutions in the SEPHADEX® column, the solutions each appeared to be light brown in color, which indicated the presence of vesicles formed from a siloxane entrapping the original concentrated calcein dye solution. Fluorescence increased very slowly, which indicated that the vesicles did not leak rapidly. The addition of twenty microliters of a ten percent by weight solution of sodium dodecylsulfate (SDS) dissolved the vesicles and caused a sudden and dramatic rise in fluorescence, which demonstrated conclusively that entrapment had occurred for each of the siloxanes. The entrapped volume was determined with the aid of a standardization curve for calcein dye.

**[0037]** The following example provides more evidence of entrapment of materials with a surface active MQ resinous siloxane.

EXAMPLE V

**[0038]** The surface active siloxanes in Example II were each added to an aqueous solution of Bromcresol Purple dye (5',5"-dibromo-o-cresol-sulfonephthalein) at a pH of four. The acid form of Bromcresol Purple dye has a dark purple color, while the base form has a bright yellow color. Vesicles formed in the solution and were observed under a Zeiss™ "Axioskop" optical microscope with Differential Interference Contrast optics. The microscope was equipped for photography of images and for real-time on-screen television viewing including video recording capability. This microscope was capable of detecting vesicles down to 200 nanometers (0.2 micrometers) in size when equipped with a 100X oil-immersion lens at a 1250X total magnification. The vesicles were observed with the microscope and a purple color was seen both on the outside and on the inside of the vesicles. When a sodium hydroxide solution was injected into the sample, an instantaneous color change was observed. The diffusion of sodium hydroxide was tracked by observing

a yellow color front. When the yellow color front contacted a vesicle and surrounded it, the purple color on the inside of the vesicle remained for one to two minutes and slowly turned to yellow. This indicated that the vesicle formed from the siloxane acted as a barrier to the diffusion of sodium hydroxide and that Bromcresol Purple was trapped within the vesicle. It further indicated that the rate of diffusion of sodium hydroxide across the vesicle was rapid.

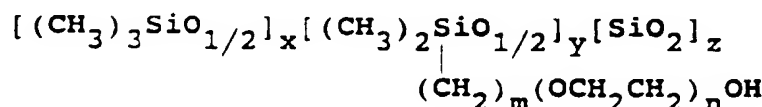
## Claims

1. A method of entrapping a water-soluble or water-insoluble substance in a vesicle formed from a surface active siloxane comprising forming a mixture by:

(a) dissolving the water-soluble substance to be entrapped in water and adding a surface active siloxane; or  
(b) combining the water-insoluble substance and a surface active siloxane;

and agitating the mixture, the surface active siloxane consisting of tetravalent  $\text{SiO}_2$  units and monovalent  $\text{R}_3\text{SiO}_{1/2}$  and  $\text{R}'\text{R}_2\text{SiO}_{1/2}$  units, the ratio of monovalent units to tetravalent units being from 0.4:1 to 2:1 and from 40 to 90% of all monovalent units being  $\text{R}'\text{R}_2\text{SiO}_{1/2}$  units, and, optionally, not more than 5% in total of trivalent units  $\text{RSiO}_{3/2}$  or divalent units  $\text{R}_2\text{SiO}_{2/2}$ , wherein R denotes a monovalent hydrocarbon group having up to 8 carbon atoms and R' denotes a polyoxyalkylene group terminated by a hydroxyl group, an alkyl group, an aryl group or an acyl group, wherein the siloxane is present in an amount of from 0.1 to 40.0 percent by weight and the water-soluble or water-insoluble substance is present in an amount of from 0.1 to 10.0 percent by weight, the balance being water or a cosolvent.

2. A method according to claim 1, in which the water-soluble substance is selected from conditioning agents, deodorant actives, antiperspirant salts, preservatives, sunscreens agents, humectants, colorants, enzymes, drugs and hydroxy carboxylic acids.
3. A method according to claim 1 in which the water-insoluble substance is selected from conditioning agents, preservatives, sunscreens agents, humectants, colorants, emollients and drugs.
4. A method according to any of claims 1 to 3, in which the polyoxyalkylene group includes oxyethylene groups and oxypropylene groups and at least 80% of the oxyalkylene groups are oxyethylene groups.
5. A method according to claim 1, in which the the surface active siloxane has the formula



wherein the ratio x/y/z is 0.5-1.5/0.3-0.6/1, m has a value of 2-8 and n has a value such that the polyoxyalkylene group has a number average molecular weight of 300 to 1000.

6. A method according to any of claims 1 to 5, wherein the siloxane is present in an amount of from 0.5 to 20.0 percent by weight.
7. A composition obtainable by the method of any of claims 1 to 6, wherein the vesicles comprise 1-99.7 percent by weight of a surface active siloxane and 0.3-99 percent by weight of the water-soluble or water-insoluble substance.
8. A composition according to claim 7 in which the water-soluble substance is selected from Vitamin C, biotin, gelatin, hydrolyzed collagen, Triclosan, aluminum chlorohydrate, aluminum/zirconium glycine, salicylic acid, DMDM hydantoin, cetyl trimethyl ammonium bromide, 4-aminobenzoic acid, 2-phenylbenzimidazol-5-sulfonic acid, glycerine, sorbitol, propylene glycol, Violet No. 2, D & C Red 22, D & C Green 8, papain, trypsin, chymotrypsin, aspirin, nicotine and hydroxyacetic acid.
9. A composition according to claim 7 in which the water-insoluble substance is selected from Vitamin A, Vitamin E Acetate, lanolin oil, 2-mercaptopyridine-1-oxide, homomenthyl salicylate, 4-methoxy cinnamic acid isoamyl ester,

lanolin alcohol, cetearyl octanoate, sodium stearyl lactylate, stearamide DIBA stearate, ethylene glycol monostearate, mineral oil, jojoba oil, polydimethylsiloxane and nitroglycerin.

## 5 Patentansprüche

1. Verfahren zum Einschluß einer wasserlöslichen oder wasserunlöslichen Substanz in einem Vesikel, das aus einem oberflächenaktiven Siloxan gebildet ist, umfassend Ausbilden einer Mischung durch:

- (a) Auflösen der wasserlöslichen Substanz, die in Wasser eingeschlossen werden soll, und Zugabe eines oberflächenaktiven Siloxans oder
- (b) Vereinigen der wasserunlöslichen Substanz und eines oberflächenaktiven Siloxans;

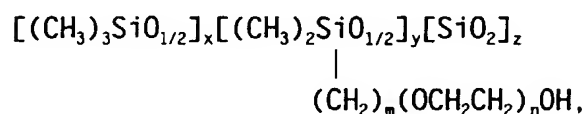
und Rühren der Mischung, wobei das oberflächenaktive Siloxan aus tetravalenten  $\text{SiO}_2$ -Einheiten und monovalenten  $\text{R}_3\text{SiO}_{1/2}$ -Einheiten und  $\text{R}'\text{R}_2\text{SiO}_{1/2}$ -Einheiten und fakultativ aus nicht mehr als insgesamt 5 % trivalenten Einheiten  $\text{RSiO}_{3/2}$  oder divalenten Einheiten  $\text{R}_2\text{SiO}_{2/2}$  besteht und das Verhältnis von monovalenten zu tetravalenten Einheiten von 0,4:1 bis 2:1 reicht und 40 bis 90 % aller monovalenten Einheiten  $\text{R}'\text{R}_2\text{SiO}_{1/2}$ -Einheiten sind, worin R eine monovalente Kohlenwasserstoffgruppe mit bis zu 8 Kohlenstoffatomen bedeutet und R' eine Polyoxyalkylengruppe mit einer endständigen Hydroxylgruppe, eine Alkylgruppe, eine Arylgruppe oder eine Acylgruppe bedeutet, wobei das Siloxan in einer Menge von 0,1 bis 40 Gew.-% und die wasserlösliche oder wasserunlösliche Substanz in einer Menge von 0,1 bis 10 Gew.-% vorhanden ist und der Rest Wasser oder ein Lösungsmittel ist.

2. Verfahren nach Anspruch 1, wobei die wasserlösliche Substanz ausgewählt ist aus Konditionierungsmitteln, desodorisierenden aktiven Bestandteilen, transpirationshemmenden Salzen, Konservierungsstoffen, Sonnenschutzmitteln, Benetzungsmitteln, Farbstoffen, Enzymen, Arzneimitteln und Hydroxycarbonsäuren.

3. Verfahren nach Anspruch 1, wobei die wasserunlösliche Substanz ausgewählt ist aus Konditionierungsmitteln, Konservierungsstoffen, Sonnenschutzmitteln, Benetzungsmitteln, Farbstoffen, Aufweichmitteln und Arzneimitteln.

4. Verfahren nach einem der Ansprüche 1 bis 3, wobei die Polyoxyalkylengruppe Oxyethylengruppen und Oxypropylengruppen umfaßt und wenigstens 80 % der Oxyalkylengruppen Oxyethylengruppen sind.

5. Verfahren nach Anspruch 1, wobei das oberflächenaktive Siloxan die Formel



aufweist, worin das Verhältnis x:y:z gleich 0,5-1,5:0,3-0,6:1 ist, m einen Wert von 2 bis 8 aufweist und n einen Wert hat, so daß die Polyoxyalkylengruppe ein zahlenmittleres Molekulargewicht von 300 bis 1.000 aufweist.

6. Verfahren nach einem der Ansprüche 1 bis 5, wobei das Siloxan in einer Menge von 0,5 bis 20 Gew.-% vorliegt.

7. Zusammensetzung, erhältlich durch das Verfahren nach einem der Ansprüche 1 bis 6, wobei die Vesikel 1 bis 99,7 Gew.-% eines oberflächenaktiven Siloxans und 0,3 bis 99 Gew.-% der wasserlöslichen oder wasserunlöslichen Substanz enthalten.

8. Zusammensetzung nach Anspruch 7, wobei die wasserlösliche Substanz ausgewählt ist aus Vitamin C, Biotin, Gelatin, hydrolysiertem Collagen, Triclosan, Aluminiumchlorhydrat, Aluminium/Zirkonium-Glycin, Salicylsäure, DMDM Hydantoin, Cetyltrimethylammoniumbromid, 4-Aminobenzoessäure, 2-Phenylbenzimidazol-5-sulfonsäure, Glycerin, Sorbit, Propylenglykol, Violett Nr. 2, C-Rot 30, C-ext. Gelb 24, Papain, Trypsin, Chymotrypsin, Aspirin, Nikotin und Hydroxyessigsäure.

9. Zusammensetzung nach Anspruch 7, wobei die wasserunlösliche Substanz ausgewählt ist aus Vitamin A, Vitamin-E-Acetat, Lanolinöl, 2-Mercaptopyridin-1-oxid, Homomenthylsalicylat, 4-Methoxyzimtsäureisoamylester, Lanolinalkohol, Cetearyloctanoat, Natriumstearylactylat, Stearamide DIBA-Stearat, Ethylenglykolmonostearat, Mineralöl,



Jojobaöl, Polydimethylsiloxan und Nitroglycerin.

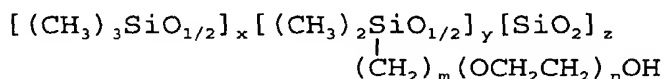
## Revendications

1. Un procédé pour encapsuler une substance soluble dans l'eau ou insoluble dans l'eau dans une vésicule formée à partir d'un siloxane tensio-actif, consistant à former un mélange :

- (a) en dissolvant dans l'eau la substance à encapsuler soluble dans l'eau et en ajoutant un siloxane tensio-actif ; ou
- (b) en combinant la substance insoluble dans l'eau et un siloxane tensio-actif ;

et à agiter le mélange, le siloxane tensio-actif étant constitué de motifs  $\text{SiO}_2$  tétravalents et de motifs  $\text{R}_3\text{SiO}_{1/2}$  et  $\text{R}'\text{R}_2\text{SiO}_{1/2}$  monovalents, le rapport des motifs monovalents aux motifs tétravalents étant de 0,4:1 à 2:1 et 40 à 90 % de tous les motifs monovalents étant des motifs  $\text{R}'\text{R}_2\text{SiO}_{1/2}$ , et, facultativement, d'au plus 5 % au total de motifs trivalents  $\text{RSiO}_{3/2}$  ou de motifs divalents  $\text{R}_2\text{SiO}_{2/2}$ , où R représente un groupe hydrocarboné monovalent ayant jusqu'à 8 atomes de carbone et R' représente un groupe polyoxyalkylène terminé par un groupe hydroxyle, un groupe alkyle, un groupe aryle ou un groupe acyle, le siloxane étant présent en une quantité de 0,1 à 40,0 pour cent en poids et la substance soluble dans l'eau ou insoluble dans l'eau étant présente en une quantité de 0,1 à 10,0 pour cent en poids, le reste étant de l'eau ou un co-solvant.

2. Un procédé selon la revendication 1, dans lequel la substance soluble dans l'eau est choisie parmi des agents de conditionnement, des agents actifs désodorisants, des sels antisudoraux, des conservateurs, des agents antisolaires, des humectants, des colorants, des enzymes, des médicaments et des acides hydroxy-carboxyliques.
3. Un procédé selon la revendication 1, dans lequel la substance insoluble dans l'eau est choisie parmi des agents de conditionnement, des conservateurs, des agents antisolaires, des humectants, des colorants, des émoullients et des médicaments.
4. Un procédé selon l'une quelconque des revendications 1 à 3, dans lequel le groupe polyoxyalkylène comprend des groupes oxyéthylène et des groupes oxypropylène et au moins 80 % des groupes oxyalkylènes sont des groupes oxyéthylène.
5. Un procédé selon la revendication 1, dans lequel le siloxane tensio-actif répond à la formule



où le rapport x/y/z est de 0,5-1,5/0,3-0,6/1, la valeur de m est de 2 à 8 et la valeur de n est telle que le groupe polyoxyalkylène ait un poids moléculaire moyen en nombre de 300 à 1000.

6. Un procédé selon l'une quelconque des revendications 1 à 5, dans lequel le siloxane est présent en une quantité de 0,5 à 20,0 pour cent en poids.
7. Une composition pouvant être obtenue par le procédé de l'une quelconque des revendications 1 à 6, dans laquelle les vésicules comprennent 1 à 99,7 pour cent en poids d'un siloxane tensio-actif et 0,3 à 99 pour cent en poids de la substance soluble dans l'eau ou insoluble dans l'eau.
8. Une composition selon la revendication 7, dans laquelle la substance soluble dans l'eau est choisie parmi la vitamine C, la biotine, la gélatine, le collagène hydrolysé, le triclosan, l'hydroxychlorure d'aluminium, le glycinate d'aluminium/zirconium, l'acide salicylique, la DMDM-hydantoïne, le bromure de cetyltriméthylammonium, l'acide 4-aminobenzoïque, l'acide 2-phénylbenzimidazole-5-sulfonique, la glycérine, le sorbitol, le propylène-glycol, le Violet N° 2, le Rouge 22 de D & C, le Vert 8 de D & C, la papaïne, la trypsine, la chymotrypsine, l'aspirine, la nicotine et l'acide hydroxy-acétique.
9. Une composition selon la revendication 7, dans laquelle la substance insoluble dans l'eau est choisie parmi la

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vitamine A, l'acétate de vitamine E, l'huile de lanoline, le 1-oxyde de 2-mercaptopyridine, le salicylate d'homométhyle, l'ester isoamylique d'acide 4-méthoxycinnamique, l'alcool de lanoline, l'octanoate de cétéaryle, le stéaroyl-lactylate de sodium, le stéaramide DIBA stéarate, le monostéarate d'éthylène-glycol, une huile minérale, l'huile de jojoba, un polydiméthylsiloxane et la nitroglycérine.

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